

MONITORING RACCOON POPULATIONS TO MAXIMIZE EFFICACY OF A FIXED-COST CONTROL BUDGET FOR REDUCING PREDATION ON SEA TURTLE NESTS

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ABSTRACT

The fundamental focus for the Hobe Sound National Wildlife Refuge on Florida's east coast is to provide and protect nesting habitat for three threatened or endangered sea turtle species. Nesting and hatching by three sea turtle species spans from early spring to fall each year. Left unchecked, predation by raccoons would destroy a high proportion of turtle nests. Raccoon removal is applied to reduce nest predation, but available funding only allows for about a one person-month control contract. We maximized the economical efficiency of this control budget by using a passive tracking index to: 1) optimize the timing and strategy for application of control, 2) minimize labor by identifying areas where control would have maximal effect, 3) examine beach invasion patterns of raccoons, 4) to assess control efficacy, and 5) provide anticipatory information for the next year's turtle nesting season.

INTRODUCTION

Urbanization and development of coastal Florida have reduced the beach areas where sea turtles can successfully nest. Raccoons (*Procyon lotor*), however, have prospered in the face of urbanization, and flourish in close company with humans where their populations often are supported by refuse or direct feeding. Raccoons are an abundant native vertebrate that impacts the conservation of endangered species (e.g., Garrett et al. 1993), as they cause substantial destruction of sea turtle nests throughout the southeastern United States (Stancyk 1982).

Hobe Sound National Wildlife Refuge (HSNWR) on the east coast of Florida offers undeveloped and protected beach habitat for nesting by leatherback (*Dermochelys coricea*), green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) sea turtles, each of which is threatened or endangered. Predation is a critical threat to many endangered or even locally rare species (Hecht and Nickerson 1999), and prior to controlling raccoons on the refuge, as many as 95% of turtle nests were destroyed in a year. In recent years, HSNWR has contracted to have predating animals removed. Budgets have allowed for annual contracts of approximately one person-month of control effort. However, turtle nesting season may begin by late January and the last hatchlings head to sea in October or November. During the interim, nests are vulnerable to predation, with predation accelerating along with the accumulation of turtle nests. Therefore, an important issue is how to best apply a limited time line of control to achieve maximum impact for protecting turtle nests.

An uncomplicated technique for monitoring raccoons that is sensitive to population changes has not been available. Predators in general are difficult to observe because of nocturnal or other secretive behaviors. An index that tracks changes in the predator population within appropriate time and geographic constraints could provide the information necessary for management decisions. Logistically more complex procedures requiring difficult-to-meet analytical assumptions, such as capture-recapture models, would be avoided (Engeman and Allen In press). A practical but valid method for monitoring raccoons on beaches would allow managers to anticipate the need and magnitude of control, target sites for most effective control, and assess the efficacy of control.

METHODS

HSNWR Turtle Nesting Beach - The beach at HSNWR is located on the northern part of Jupiter Island, a narrow, 27 km-long barrier island separated from the mainland by the Peck Lake Intracoastal Waterway. St. Lucie Inlet State Park, another area of protected habitat, is north of HSNWR and the town of Jupiter is located

south of the refuge. HSNWR protects approximately 5.3 km of beach, which is open to the public during daylight hours, but is accessible only by boat, or by foot from the southern boundary.

Raccoon control methods - Control efforts are carried out at night, because raccoons are nocturnal. Removal of raccoons, even to protect endangered species, has been a controversial issue (Smith 2000), but since the refuge is closed to the public at night the potential for interference is minimized. Because the two primary raccoon removal methods are labor intensive, it is important that their application be as efficient as possible. Raccoons are hunted along the beach at night using a .22 cal rifle equipped with a noise suppressor, and cage traps are used to capture animals that are then euthanized. At the end of each night, traps are removed to avoid vandalism.

Placement of tracking plots - The tracking methodology we used was similar to that described by Allen et al. (1996) for dingoes (*Canis lupus dingo*) and Engeman et al. (2000) for coyotes (*Canis latrans*) and coexisting animals. However, in each of those applications tracking plots were placed on dirt roads, because they were used as travel pathways by the animals. Raccoons had been successfully monitored along roads using the same methodology in Texas, but was unsuccessful using off-road plots (Engeman and Allen In Press). No roads existed along the beach at HSNWR, so an alternative approach was needed.

The HSNWR beach varies in slope and width, and has a well-defined dune line. Observation of raccoon tracks indicated that the animals typically followed the dune line, and this is where we placed tracking plots. Plots were approximately 2 x 3 m, discreetly marked by stakes in 2 corners to avoid detection by animals or interference by humans, and smoothed to produce a good tracking base. We observed the same plots for 2 consecutive days at each assessment. The locations of all plots were recorded using a GPS receiver. A total of 21 plots were placed approximately 200 m apart, avoiding the short beach segments frequented by people.

Index calculations - The passive tracking index (PTI), variance estimates, components of variance, and statistical tests to compare index values were calculated according to Engeman et al. (1998). The number of sets of tracks (individual intrusions into the plot) are recorded for each plot each day. The mean number of intrusions over the plots is calculated for each day, and the index is the mean of the daily means. Observations from all tracking plots were used to calculate index values for the entire HSNWR beach. Although sample sizes were necessarily small, we also examined invasion of the beach by raccoons by calculating indices using subsets comprised of just the 4 southern-most and the 4 northern-most plots.

Assessment timing - Tracking plot observations were first carried out in January 2000, prior to initiation of turtle nesting. The same plots were observed again in mid-May to assess raccoon population increases along the beach as turtle nesting reached full momentum. Another assessment was made in early June as predation appeared to accelerate. Efficacy of two weeks of raccoon control was evaluated in early August, and repopulation patterns were monitored in mid-August. Raccoon populations post-turtle nesting/hatching were examined in November.

RESULTS

Timing of control - A preventative strategy for efficiently reducing damage in some situations is to reduce animal populations before damage begins (Ramsey and Wilson 2000). This approach was a consideration for HSNWR, whereby raccoons would be removed prior to turtle nesting. However, the initial indexing session demonstrated a near absence of raccoons along the beach, indicating that raccoons invade the beach during turtle nesting season. Initiating control before nesting would have been a fruitless expenditure of limited resources. Thus, a corrective control strategy was adopted whereby animals were monitored until intervention was indicated.

Raccoon numbers abruptly increased along the beach within a month (early June) after turtle nesting had hit reached full momentum in mid-May (Table 1). Thus, raccoon removal was initiated in June, and these efforts greatly reduced raccoon numbers along the beach (early August assessment). An indication of re-invasion, particularly from the south, was found by mid-August, and another round of control was implemented with

the remainder of the contract funds. The post-nesting and hatching assessment showed sparse raccoon activity similar to that from the pre-nesting assessment in January.

Table 1. Passive tracking index calculations from Hobe Sound National Wildlife Refuge beach for 2000 using 21 plots spanning the length of the beach, and the 4 plots nearest the southern boundary, and the 4 plots nearest the northern boundary.

<u>Date</u>	<u>Index Values</u>			<u>Event</u>
	<u>All 21 plots</u>	<u>South 4 plots</u>	<u>North 4 plots</u>	
mid-Jan	0.07	0.13	0.00	Pre-turtle nesting
mid-May	0.31	0.00	0.25	Turtle nesting fully under way
Early June	1.17	0.00	5.25	Pre-raccoon control
Early Aug	0.14	0.38	0.00	Post-control
mid-Aug	0.20	0.38	0.00	Re-invasion
mid-Nov	0.05	0.00	0.00	Post-nesting

Placement of control for efficiency of labor - The tracking plots provided a view of raccoon activity along the full length of HSNWR beach, informing control personnel where to focus control efforts, particularly hunting, to achieve the greatest impact. Raccoon activity varied along the beach. Index values from the north and south ends of the beach showed divergent levels of activity at given times during turtle nesting (Table 1). In between the two geographic extremities, different segments of beach presented different levels of activity, independent of readily apparent habitat factors. Knowledge of hot spots of activity allowed control efforts to concentrate more heavily on these sections, thus minimizing time and labor for removing raccoons.

Efficacy - An obvious objective for monitoring raccoon activity HSNWR beach was to evaluate whether control efforts had an impact. Data in Table 1 show increasing raccoon activity through the June assessment, with an abrupt decline following control to an index level half the mid-May assessment, which was before raccoon activity increased in response to turtle nesting.

Raccoon invasion and re-invasion of the nesting beach - Understanding patterns and timing of movement of raccoons onto the beach during turtle nesting could facilitate the development of control strategies. Consider that the town of Jupiter Island on the southern border of the refuge is the wealthiest in the United States (Nguyen 2000), and consequently a large portion of its residents leave for residences outside Florida with the onset of the heat and humidity of summer. Potentially, a summer exodus of residents could result in a reduction in food resources for raccoons for a period coincidental with the greatest turtle nesting activity. If true, raccoons could be expected to invade HSNWR beach from the urban areas to the south in search of plentiful turtle eggs. In contrast to this hypothesis, the tracking plot data (Table 1) indicated that the initial raccoon invasion of the beach area was heaviest in the more remote northern areas of the refuge, despite the southern third of the beach exhibiting nearly twice the nesting rate as the northern third (Ecological Associates Unpublished data). However, monitoring in early August for repopulation subsequent to control revealed that re-invasion of the beach area was from the south. The observations may be explained by the combination of raccoon removal creating a vacuum along the beach and the town raccoons possibly having a reduction food resources.

DISCUSSION

We used a passive tracking index to 1) optimize the timing and strategy for application of control, 2) minimize labor by identifying areas where control would have maximal effect, 3) examine beach invasion patterns of raccoons, and 4) assess control efficacy. A similar control contract was in place for 1999, but that control was carried out without the benefit of the additional information provided by the tracking plot data. There are undoubtedly many variables that influence depredation rates, including potential carryover effects of control from one year to the next. Bearing this in mind, the depredation rate in 1999 was 42% (Ecological

Associates 2000), 50% greater than in 2000 when total estimated depredation was down to 28% (Ecological Associates Unpublished data).

Another benefit from the tracking plot data was that it provided anticipatory information for the next year's turtle nesting season. Continued monitoring would further establish whether the raccoon activity patterns observed during the 2000 turtle nesting season represent general characteristics of behavior. If so, this knowledge could lead to greater precision in the timing and spatial focus of control. For example, next season we would expect to focus removal efforts on the north end of the HSNWR beach early in the nesting season, and then expect to encounter more raccoon invasion from the southern portion of the island in mid to late summer. Acquisition of technologically improved control tools for the next nesting season should increase the impact achieved from the tracking plot data. These include using night vision scopes and infrared laser sighting on the suppressor-equipped rifles to further reduce raccoon wariness. Also, EGGTM traps, which are highly selective and effective for capturing raccoons while minimizing injuries (Hubert et al. 1996), may be applied to provide a lightweight and efficient means to capture raccoons in addition to the bulky live traps. Continued monitoring of raccoon invasion from the urban areas to the south of the refuge may provide evidence of their potential for impact on turtle nesting.

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